

DRAGAN BADANJAK, D.Sc.
E-mail: dragan.badanjak@fpz.hr
University of Zagreb,
Faculty of Transport and Traffic Sciences
Vukelićeva 4, HR-10000 Zagreb, Republic of Croatia

MARIJAN RAJSMAN, D.Sc.
E-mail: marijan.rajsman@zagreb.hr
Gradski ured za prostorno uređenje, zaštitu okoliša,
izgradnju grada, graditeljstvo, komunalne poslove i promet
Trg Stjepana Radića 1, HR-10000 Zagreb,
Republic of Croatia

ČEDOMIR DUNDOVIĆ, D.Sc.
E-mail: cedomir.dundovic@pfri.hr
University of Rijeka, Faculty of Maritime Studies
Studentska 2, HR-51000 Rijeka, Republic of Croatia

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DEVELOPMENT OF RIVER TRAFFIC IN THE TRAFFIC SYSTEM OF CENTRAL CROATIA

ABSTRACT

From the aspect of public transport of passengers and goods, the traffic system in Central Croatia consists of road, rail, air and river subsystems. Regarding their share in the volume of passenger and cargo transport as well as the carried out transport operations in the traffic system of Central Croatia, road and rail traffic are the dominant traffic subsystems. Regarding its technical, technological, organizational and economic indicators, the river traffic system represents the less developed subsystem of the traffic system of Central Croatia, and the situation in this respect is not much different at the national level either.

The possibilities for the development of river traffic system have not been sufficiently used, although the potential traffic demand for the transportation services are substantial, especially when considering the river Sava which potentially offers a direct connection to the trunk European waterway. The advantages of the Central Croatian location undoubtedly lie in the traffic and geo-strategic position, but the value of this location can be used only then when the quality level of the traffic system and the construction level of the infrastructure catch up with the ones in the developed European countries. The conditions for the traffic development are first of all strong and daily faster changes in the strata, especially regarding the implementation of new solutions and increasing the efficiency of the overall traffic system. It is precisely for this reason that special interest should be to study the traffic values according to the available data, establish their possible rules as function of time, and design appropriate mathematical models with the aim of forecasting the traffic development in the future.

KEY WORDS

development, traffic, system, model, forecast, trend

1. INTRODUCTION

Transport demand has crucial significance in determining and managing the traffic policy, determining the development level of the traffic system, as well as the level of its utilization.¹

The scientific approach to the study of traffic system development, including its river subsystem consists also of the study of adequate traffic values and establishing of laws according to which they acquire their values during the observed period of time. The basic assumption of the development of transport capacities is the knowledge about the volume of passenger and goods transport, i. e. the traffic demand forecast within the studied traffic system. Forecast is the evaluation of the phenomenon, process or state, which is expected with high probability in a certain period in the future, and it is the result of quantitative and qualitative development in the previous period.²

2. TRAFFIC SYSTEM OF CENTRAL CROATIA

From the aspect of public transport of passengers and goods the traffic system of Central Croatia consists of its road, rail, air and river subsystems. Regarding their share in the volume of passenger and cargo transport as well as performed transport work in the traffic system of Central Croatia road and rail traffic are their dominant traffic subsystems.

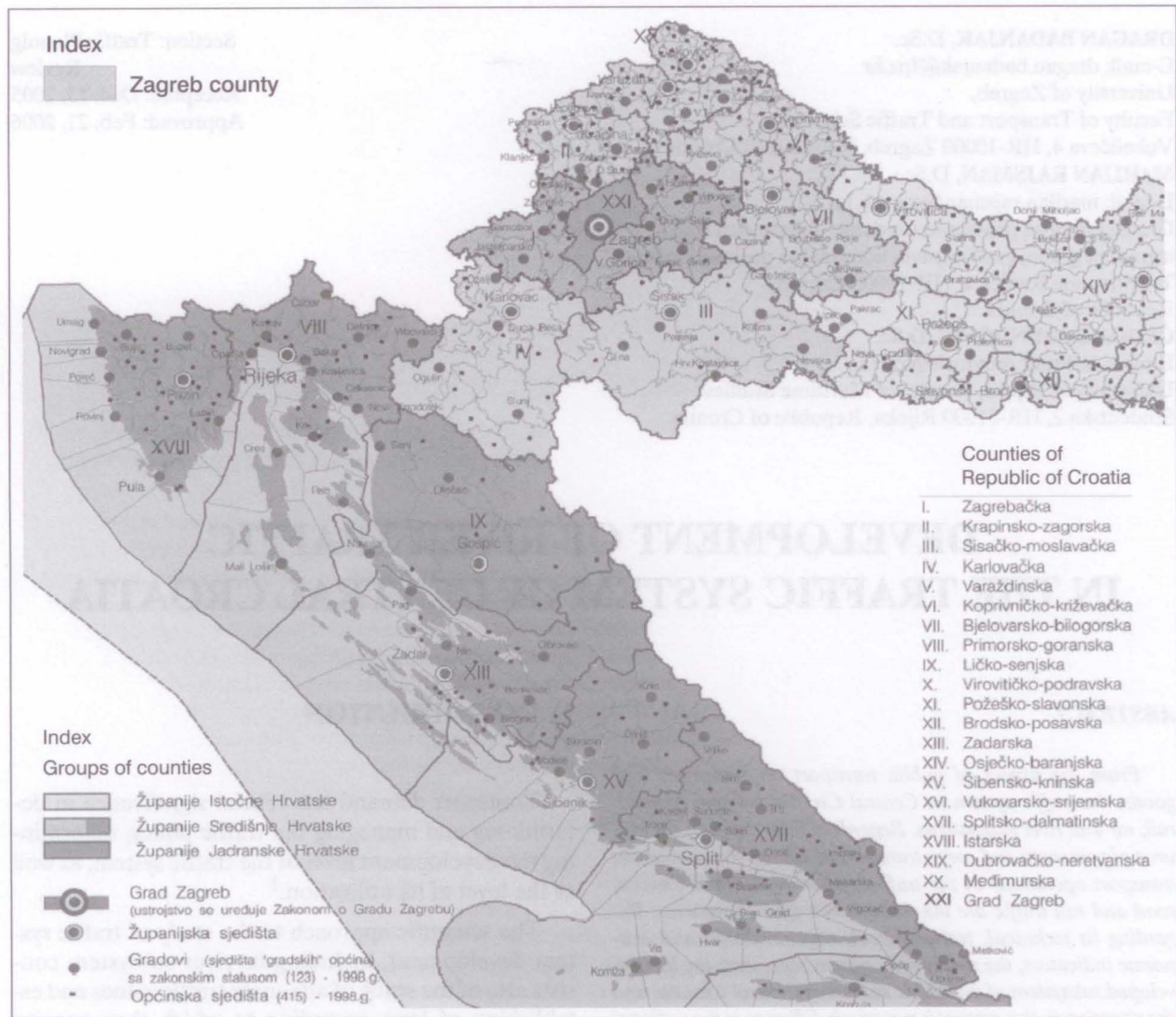


Figure 1 - Counties of Central Croatia according to the Strategy of spatial planning of the Republic of Croatia

Source: Strategy of spatial planning of the Republic of Croatia, NN 50/1999

2.1. Traffic valorisation of Central Croatia

The significance of the traffic valorisation as complex scientific and professional activity lies precisely in the fact that it precedes the determination and creation of a consequent traffic policy.³ The criteria of traffic valorisation of Central Croatia are the qualitative and quantitative capability of transport of its traffic system, transport costs, level of impact of the traffic system on the organisation of space and development of the region as the precondition of its progressive role and the development generator of the entire Croatian national region. The space dimension particularly includes valorisation not only regarding the needs and possibilities of Central Croatia and the national traffic system, but also the needs, possibilities and the interest of Europe.⁴

In the strategy of spatial planning of the Republic of Croatia (map in Figure 1) Central Croatian region

is defined as the most developed Croatian area and the crucial junction of the European and regional traffic corridors.

This region has extreme traffic and geographic and economic significance, and at the same time it is the central national area. The emphasised role of this region lies in its function as the natural connecting region between the Adriatic Sea and the mountainous hinterland.⁵

The advantages of Central Croatia lie undoubtedly in its traffic and geostrategic location, but the values of this location can be used only when the level of the traffic system quality and the level of construction of the traffic infrastructure come close to those in the developed European countries.

On the Sava traffic corridor there already exist navigable river waterways from Sisak towards Slavonski Brod and Županja. After the construction of the Danube-Sava canal from Vukovar to Šamac and

by canalizing the Sava river, the region of Central Croatia will become especially significant, particularly regarding its positive influence of the combined railway-river traffic from the Danube basin towards the Kvarner Bay.

3. CHARACTERISTICS OF TRAFFIC DEVELOPMENT OF CENTRAL CROATIA

In this section a brief review is given on the basic features of the European, national traffic system and the traffic system of Central Croatia.

3.1. Characteristics of the traffic development of the European Union

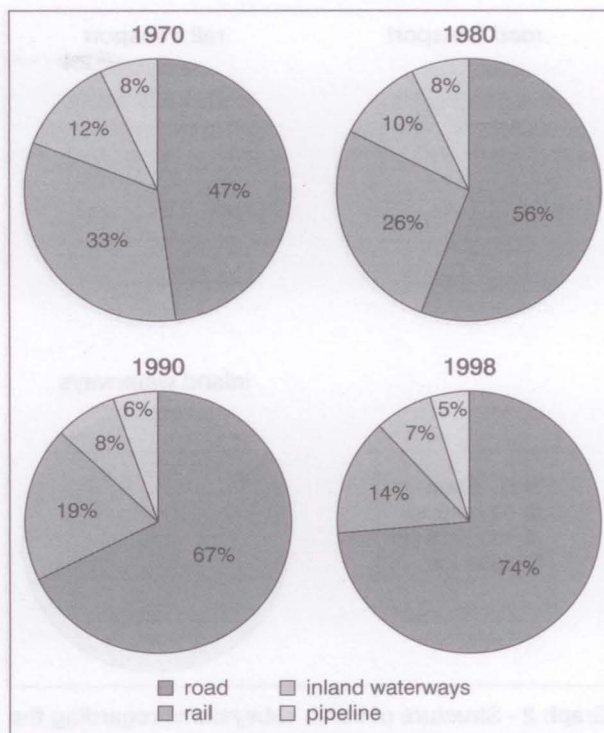
In January 2006 the European Commission published the action plan of stimulating cargo transport on inland waterways with the aim of improving the transport conditions in the European Union traffic system. The possibilities of increasing the absolute and relative share of river traffic and channel subsystem (ca. 30 thousand kilometres of navigable waterways) in the transport substrate volume and the realized transport operation are reflected also in the data on the static transport capacity and the potential of this subsystem and fleet of 11 thousand vessels, which corresponds to the capacity of 10 thousand trains, i. e. 440 thousand cargo road vehicles, which may render the traffic in Europe more efficient, more reliable, and environmentally friendlier, with positive effects of alleviating the road subsystem in particular.⁶ This action plan will come into force by 2013 and will concentrate on five key parameters:

- transport service quality,
- fleet modernisation,
- professional improvement and training of crews,
- subsystem "image",
- infrastructure.

The White Paper⁷ of the European Commission defines the basic objective as part of the unique European traffic system which consists in the integration of national traffic infrastructures and suprastructures (refers to modernisation, standardisation, automation, informatisation).⁸

Over the recent thirty years (according to Graph 1) in the European Union countries in the structure and dynamics of the cargo transport demand development, the following can be stated:

- significant and constant increase in the share of road traffic subsystem, which at the end of this period amounts to 74% (increase by 37% compared to the beginning of the period),
- significant and constant reduction in the share of railway subsystem which at the end of this period



Graph 1 - Dynamics of share of traffic subsystems of the European Union countries in the structure of the entire cargo transport demand

Source: Statistical overview of road, rail, inland waterways and air transport in the European Union: Panorama of transport, European Commission, 2001

amounts to 14% (decrease by 19% compared to the beginning of this period),

- gradual decrease in the share of inland waterway subsystem which at the end of this period amounts to 7% (decrease by 5% compared to the beginning of the period).

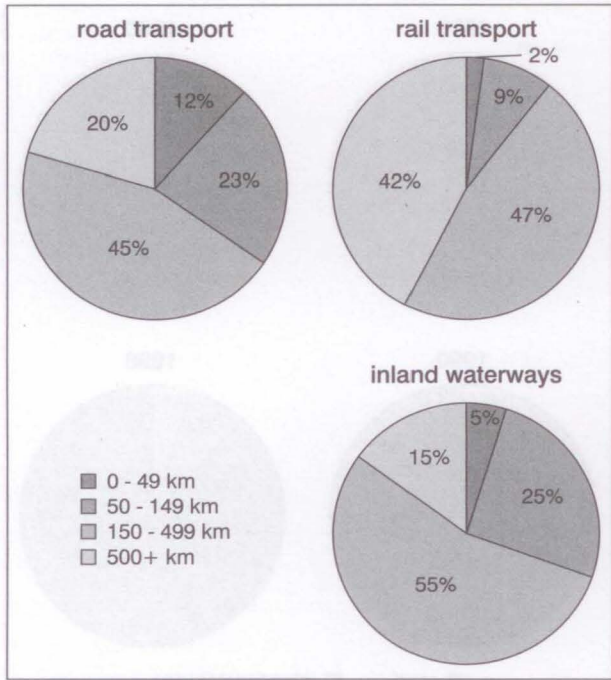
It may be concluded that 88% of the demand for transport services in cargo traffic of the European Union are operated in road and railway traffic subsystem.

Graph 2 indicates the structural distribution and relative shares of the traffic subsystems within the traffic system of the European Union in satisfying the cargo transport demand regarding the relation on which the transport is performed:

1. river traffic subsystem
 - 55% on relations from 150 to 500 km,
 - 25% on relations from 50 to 150 km,
 - 15% on relations over 500 km,
 - 5% on relations up to 50 km.

The term of the European navigable waterway (presented in Figure 3) is increasingly present in Europe, defined as international inland waterway which connects major European ports and industrial centres.

Among numerous objectives the strategy of the traffic system development of the European Union refers to the improvement of the traffic infrastructure



Graph 2 - Structure of traffic subsystems regarding the traffic relation in cargo traffic of the European Union countries

Source: Statistical overview of road, rail, inland waterways and air transport in the European Union: Panorama of transport, European Commission, 2001

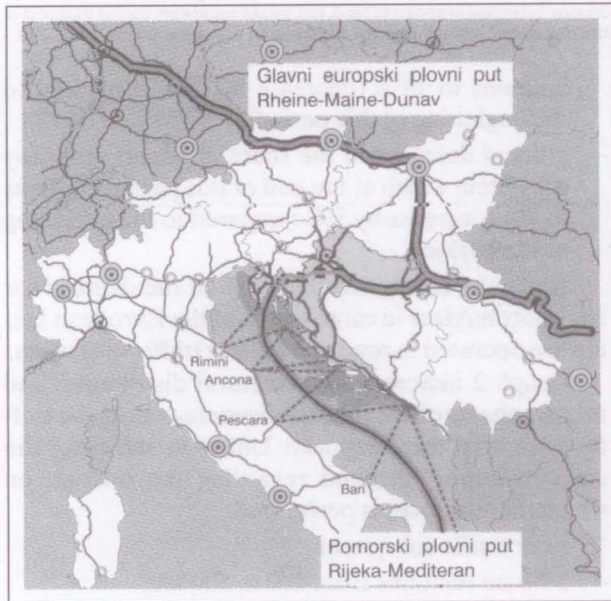


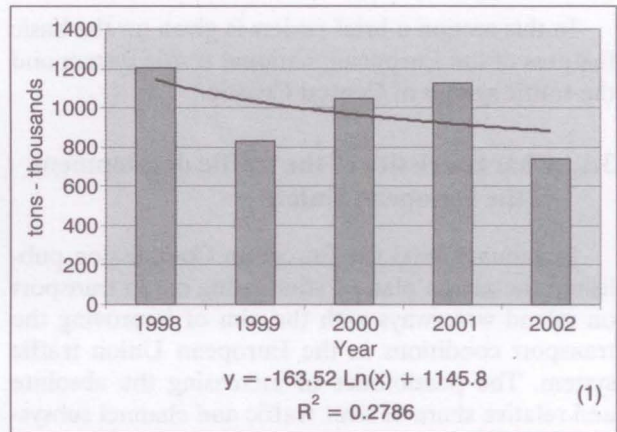
Figure 2 - Part of the main European navigable waterway regarding Central Croatia

Source: Strategy of the traffic development of the Republic of Croatia

and suprastructure, their rational utilization, higher traffic safety, better work conditions, environmental protection, implementation of sustainable development principles, preference of traffic subsystems (regarding minimization of fuel consumption, maximal effects, environmental protection, investment maintenance) of the sea, river, and rail traffic.

3.2. Characteristics of the development of the Croatian traffic system

The past development of the Croatian traffic system in the period from 1970 to 2000 was characterised by extensively developing road traffic infrastructure and excessive investments in the road traffic subsystem, neglecting the development of other subsystems, i. e. their infrastructure.⁹

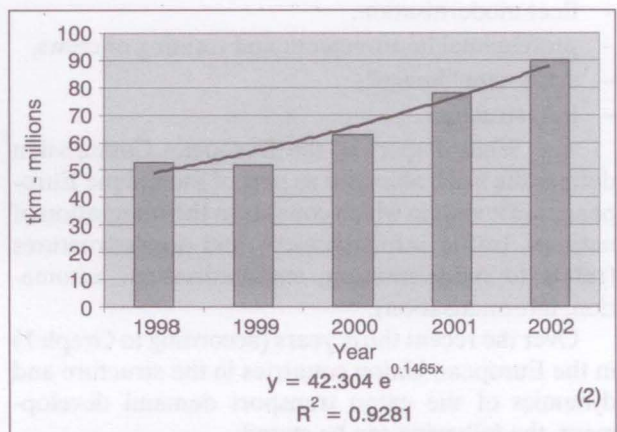


Graph 3 - Dynamics of the transport substrate in the river traffic subsystem of the Republic of Croatia in the period from 1998 to 2002

Note: Forecast trend model of the development dynamics of the carried transport substrate in river traffic subsystem of the Republic of Croatia is given by the equation (1) and it is presented in the graph.

Source: Statistical reports 1197 for 2002. State office for statistics of the Republic of Croatia, Zagreb, 2003

Mathematical statistical analysis of the data on the carried transport substrate in river traffic subsystem of the Republic of Croatia during the studied period yields the equation of prognostic trend model (1) and the determination coefficient value R^2 .



Graph 4 - Dynamics of cargo transport operation of river traffic subsystem of the Republic of Croatia in the period from 1998 to 2002.

Note: Prognostic trend model of development dynamics of cargo transport operation of the river traffic subsystem of the Republic of Croatia is given by equation (2) and is presented in the graph.

Source: Table 1.

The determination coefficient (R^2) measures the strength of the connection of the studied variable in the mathematical model and time. If the connection is functional then the value of the determination coefficient $R^2 = 1$, and the closer the R^2 to this value, the stronger the connection.¹⁰ When the value of the determination coefficient R^2 is greater than 0.77 it may be concluded that the determined mathematical model of the prognostic trend of the studied variable is statistically significant.¹¹

The prognostic trend model equation (2) and the value of the determination coefficient R^2 were obtained during the studied time period by means of the mathematical statistical analysis of the data regarding the cargo transport operation of the Croatian traffic subsystem.

3.3. Characteristics of the development of river traffic subsystem of Central Croatia

The national inland waterways consist of the rivers: Sava, Drava, Danube and Kupa. They have a common characteristic that none of them, except the Danube, have been regulated for inland navigation. The navigation along the river Sava proceeds in spite of absence of maintenance; vessels navigate along the river Drava as well, but it is of local significance, whereas the Kupa has not been regulated for navigation at all.¹²

Regarding the significance and share of the national river traffic subsystem, Aržek states also the following characteristics:¹³

- lack of regulation of the waterways,
- obsolete fleet capacities.

This results in the basic objectives of river traffic subsystem development:¹⁴ regulation of the waterways, and modernization of the fleet capacities. The navigable rivers in Central Croatia are: Sava – from the mouth of the river Kupa into Sava near Sisak, Drava – from Barča, Kupa – to the rivermouth into the Sava upstream to the river port in Sisak.

The crucial thing for the development of the river traffic subsystem of Central Croatia is to regulate the Sava for the navigation on its entire navigable flow through Croatia to Sisak, with simultaneous construction of the Zagreb river port in the place of Rugvice.

River traffic is the Croatian traffic subsystem most lagging behind, although its potential role is very significant for the economy, first of all due to its relying on the central European waterway which connects the North and the Black Sea.¹⁵

The Croatian river ports have kept the characteristics they have had over the past thirty years. The investments into the modernisation are modest, so that the level of port service has not improved substantially. Not one of the river ports has the capacities

Table 1 - Traffic values of the river subsystem

Traffic Volume	Region	Year				
		1998	1999	2000	2001	2002
Total transported cargo (thou. tons)	CRO	1206	833	1045	1123	739
	Central CRO	647	240	377	563	230
Total cargo transport operation (tkm, mil.)	CRO	53	52	63	78	90
	Central CRO	46	48	56	70	85
Transported cargo in inland transport (thou. tons)	CRO	1139	738	996	1088	683

Source: Statistical reports 1197, Državni zavod za statistiku Republike Hrvatske, Zagreb, 2003, Ministarstvo pomorstva, prometa i veza Republike Hrvatske, 2003.

which would enable container or Ro-Ro transport. In spite of this, the Croatian river ports mark an increase in the annual volume of cargo handling, which provides reasons for potential investments both into the ports and the port infrastructure.¹⁶

River traffic is substantially lagging behind in comparison to the European characteristics of river traffic. The lagging behind is reflected in the lack of regulation of the navigable waterways, and in the insufficient number of constructed and adequately equipped river berths, out of which Sisak on the river Sava is included in the big Croatian river ports, and has large potential significance in the river traffic subsystem of Central Croatia. Future development of this port is possible due to the vicinity of Zagreb, as big logistic and industrial centre, and based on its own industrial structure, based on the ironworks and oil refinery.

According to the data of the State Office for Statistics the annual share of river traffic in the total carried cargo in the Republic of Croatia during the nineties amounts to 1.5%. In absolute figures this is approximately 1.2 million tons of carried cargo annually. On the contrary, in the Danube basin countries the range of such share is 10 – 20%.¹⁷

The port Zagreb-Rugvica has extreme significance, since it is in the near vicinity of the biggest Croatian industrial and traffic junction and can serve the needs of a wider catchment area of the city of Zagreb, not excluding the port of Sisak and its known and defined role regarding the requirements of oil, chemical industry and black metallurgy. This statement is confirmed by Brkić presenting data that in some European countries the share of river traffic is 20 to 30%, and in Croatia about 4% of total traffic, which indicates high possibilities of developing this traffic subsystem as one of the least expensive ones in the traffic system.¹⁸

4. MODELLING OF TRAFFIC SYSTEM DEVELOPMENT

The characteristic of the unity of the production process and the consumption of transport service is the cause of marked need for transport capacity planning based on the demand tendency for traffic services.¹⁹ The approach to the management of traffic system and its subsystems²⁰ requires the implementation of mathematical theory which allows the design of adequate mathematical models, with the aim of simulating numerous situations of system behaviour. The system behaviour is presented in a series of function values of the traffic magnitudes expressed in the form of tables and respective graphs. In this process it is necessary to have maximally accurate information about the past events and development trends of system behaviour in the future.²¹

5. RIVER TRAFFIC SYSTEM DEVELOPMENT

For the traffic system of the Republic of Croatia and for the more significant role of the river subsystem, special significance lies on the regulation of the river Sava. In this sense the focus is on the river Sava regulation project which was developed in 1972 in cooperation with the UN experts. The realization of this project is part of the preparations which would include this river, apart from the Danube and the Drava, into the Trans-European network of navigable waterways.²²

The basic corridors of river traffic are related to the Danube with which Croatia, via Rhein-Main-Danube canal is connected to the Rheine and Danube navigable system. Inland waterways in the Republic of Croatia have been integrated into the network of European waterways of the corridor VII (the Danube). This would include both the river Drava from the mouth to Osijek (E-80-08), the river Sava to Sisak, (E-80-12), and future Danube-Sava canal, (E-80-10) into the international waterways. Canalizing is planned of the river Sava from Sisak to Rugvica, i. e. if the needs require also of the river Kupa from Sisak to Karlovac.²³

The mid-term development (the next five to ten years) of river traffic subsystem of Central Croatia contains the following:

- construction of a port in Sisak,
- canalizing of the Sava from Sisak to Šamac,
- development of modern cargo distribution terminals with the application of advanced transport technology (combined and multimodal transport and introduction of telematic systems).²⁴

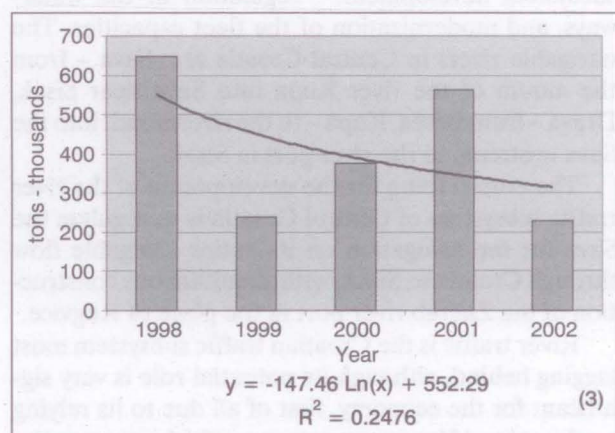
The strategy and program of spatial planning of the Republic of Croatia place greater significance on the river traffic and indicate the need for investment into the infrastructure of the river waterways in order to redirect single types of cargo to river traffic. The projection of river port network in Croatia includes three big ports: Vukovar, Osijek and Sisak, and according to development and the industrial needs the port of Zagreb. It is necessary to regulate the navigable waterway of the river Drava from Terezino Polje to Ždalica into navigability class II in order to establish river traffic in the county of Koprivnica – Krževci.²⁵

The strategy of the traffic development of the Republic of Croatia plans canalizing of the river Drava. With the river traffic development, the development of a series of new cargo, transport and production centres is planned (Figure 3). The regulation of the navigable waterway would solve the drainage, irrigation and protection against floods.

For all the works on the common sections of the rivers of the Sava and the Drava an agreement is necessary with the neighbouring countries.

A graphical presentation is given as well as the mathematical statistical analysis of the traffic values in Table 1 during the studied five-year time period from 1998 to 2002. The prognostic trend model of the development dynamics of individual traffic values has been obtained by means of the computer program "Microsoft Excel" determined by the equation and determination coefficient, and presented in the graph.

The mathematical statistical analysis of the data of the carried transport substrate in the river traffic subsystem of Central Croatia during the studied period yields the equation of the prognostic trend model (3) and the value of the determination coefficient R^2 .



Graph 5 - Dynamics of the transport substrate in the river traffic subsystem of Central Croatia in the period from 1998 to 2002

Note: The prognostic trend model of development dynamics of the carried transport substrate in river traffic subsystem of Central Croatia is given by equation (3) and presented in the graph

Source: Table 1

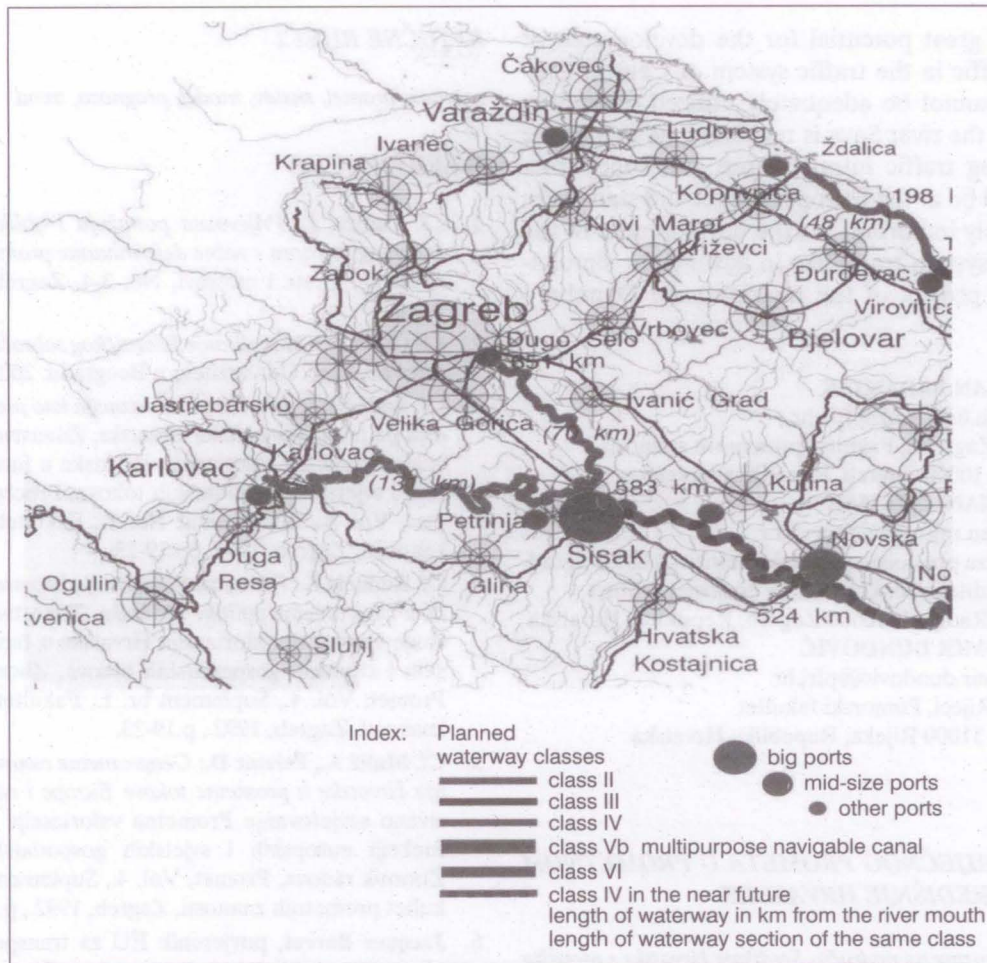
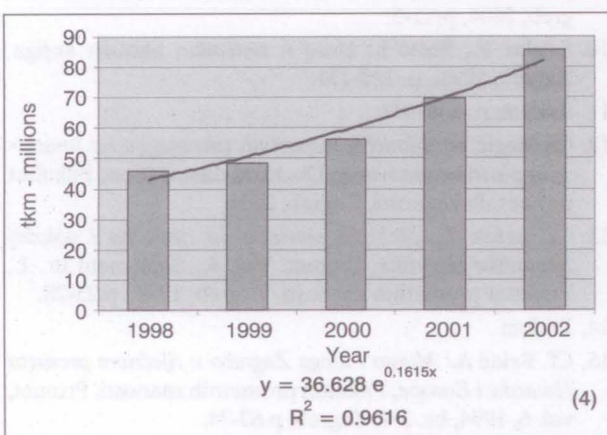


Figure 3 - Possibilities of the development of inland waterways of Central Croatia

Source: Strategy of the Spatial Planning of Croatia, NN 50/99.

During the studied period the mathematical statistical analysis of the data about the development of cargo transport operation on the river traffic subsystem of Central Croatia yields the equation of the prognostic trend model (4) and the value of determination coefficient R^2 .



Graph 6 - Dynamics of cargo transport operation of river traffic subsystem of Central Croatia in the period from 1998 to 2002

Note: The prognostic trend model of the development dynamics of cargo transport operation on the river traffic subsystem of Central Croatia is given by the equation (4) and presented in the graph

Source: Table 1

tem of Central Croatia yields the equation of the prognostic trend model (4) and the value of determination coefficient R^2 .

According to the performed mathematical statistical analyses of the studied traffic values of Central Croatia from Table 1 in the period from 1998 to 2002 the statistically significant ($p < 0.05$) trend model has been determined for the dynamics of cargo transport operation on the river traffic subsystem.

6. CONCLUSION

The development of the traffic system is based on the strategic goals which are achieved by adequate assessment of the geotrafic position of the counties of Central Croatia compared to the network of the main traffic corridors of the state and their integration into the network of European corridors. The traffic policy measures and the influence of traffic values can cause changes in the behaviour of a certain traffic subsystem, and change the relationship among traffic subsystems and model the traffic system development.

There is great potential for the development of the river traffic in the traffic system of Central Croatia which cannot be adequately utilized unless the waterway of the river Sava is regulated, as well as the accompanying traffic infrastructure and suprastructure that will be at the European level and standards. It is extremely important for the development of the river traffic system to realize in advance or simultaneously the project of the multipurpose Danube – Sava canal.

Dr. sc. DRAGAN BADANJAK

E-mail: dragan.badanjak@fpz.hr

Sveučilište u Zagrebu, Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska

Dr. sc. MARIJAN RAJSMAN

E-mail: marijan.rajsman@zagreb.hr

Gradski ured za prostorno uređenje, zaštitu okoliša, izgradnju grada, graditeljstvo, komunalne poslove i promet
Trg Stjepana Radića 1, 10000 Zagreb, Republika Hrvatska

Dr. sc. ĆEDOMIR DUNDOVIĆ

E-mail: cedomir.dundovic@pfri.hr

Sveučilište u Rijeci, Pomorski fakultet
Studentska 2, 51000 Rijeka, Republika Hrvatska

SAŽETAK

RAZVITAK RIJEČNOG PROMETA U PROMETNOM SUSTAVU SREDIŠNJE HRVATSKE

Prometni sustav na području Središnje Hrvatske s motrišta obavljanja javnog prijevoza putnika i roba čine cestovni, željeznički, zračni i riječni podsustav. Cestovni i željeznički promet po svom udjelu u obujmu putničkog i teretnog prijevoza kao i izvršenom transportnom radu u prometnom sustavu Središnje Hrvatske jesu njegovi dominantni prometni podsustavi. Riječni prometni sustav po svojim tehničkim, tehnološkim, organizacijskim i ekonomskim pokazateljima predstavlja najslabije razvijen podsustav prometnog sustava Središnje Hrvatske, a situacija u tom pogledu nije bitno različita niti na nacionalnoj razini.

Mogućnosti za razvitak riječnog prometnog sustava nisu u dovoljnoj mjeri iskorištene, iako su potencijalne prometne potrebe za prijevoznim uslugama znatne, posebice ako se uzme u obzir postojanje rijeke Save koja potencijalno omogućuje izravan priključak na glavni europski plovni put. Prednosti prostora Središnje Hrvatske neosporno su u prometnom i geostrateškom položaju, ali vrijednosti tog položaja mogu se u iskoristiti tek kad se razina kvalitete prometnog sustava i izgrađenosti prometne infrastrukture približi onoj u razvijenim zemljama Europe. Uvjeti u kojima se odvija prometni razvitak u prvom redu jesu snažne i svakim danom sve brže promjene u njegovim stratumima, posebice u smislu primjene novih rješenja i povećanja učinkovitosti cjelokupnog prometnog sustava. Upravo stoga od posebnog je interesa prema dostupnim podacima istražiti prometne veličine, ustanoviti njihove eventualne zakonitosti u funkciji vremena, te oblikovati odgovarajuće matematičke modele u svrhu predviđanja prometnog razvika u budućem razdoblju.

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razvitak, promet, sustav, model, prognoza, trend

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